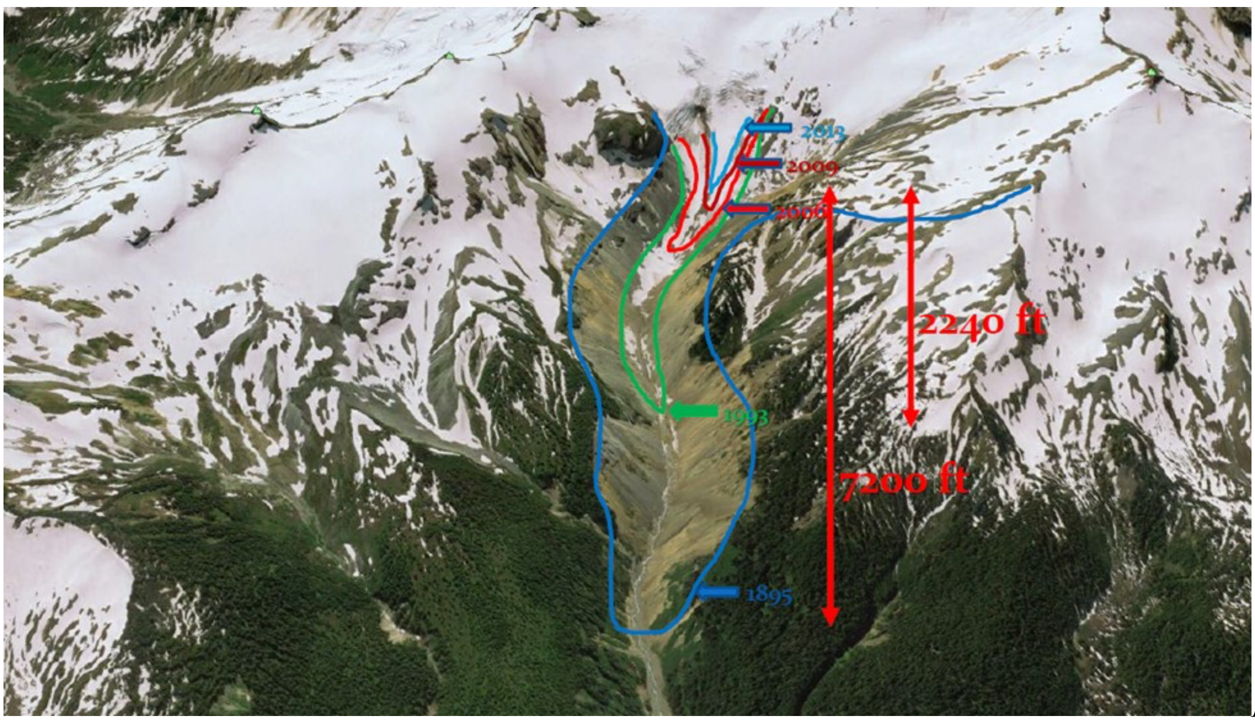
Nooksack Indian Tribe - https://nooksacktribe.org/departments/natural-resources/water-resources/glacial-monitoring/

Glacial Monitoring

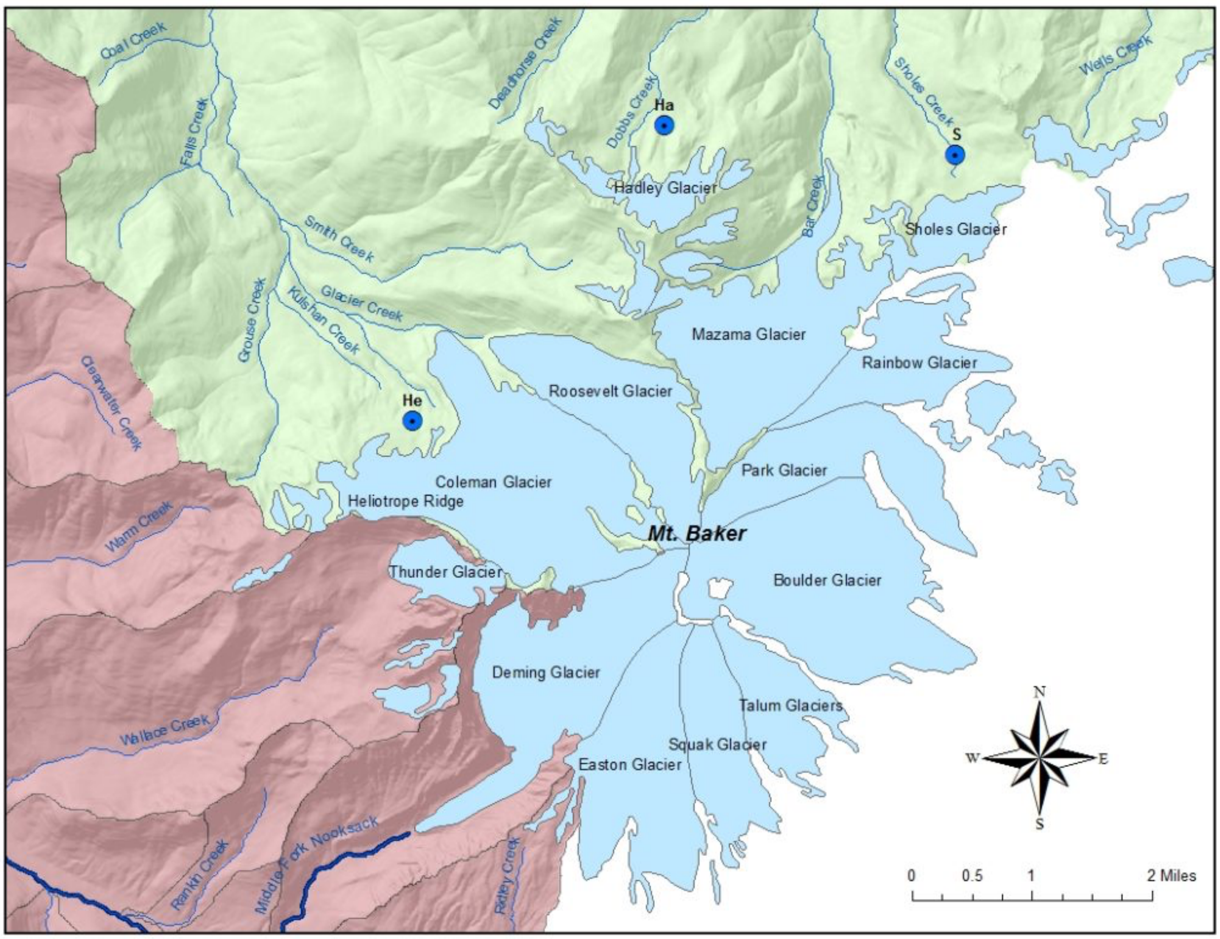
Trends in climate change since the 1900's in the Pacific Northwest suggest that warming of the climate has occurred and will likely continue to occur, resulting in wetter falls, winters, and springs, but drier summers. More intense rainfall on areas usually covered and protected by snow and glaciers will be more prone to erosion, entrainment, and transport of sediment to streams thereby increasing sediment loads. Glaciers in the Nooksack River watershed that support summer flows have been shown to be receding and losing volume. An analysis of glacier melt contribution to the North Fork during warm periods in August 2015 suggest that as much as 60-95% of the total streamflow was comprised of glacier melt. This emphasizes the importance of glacial melt augmenting flows in the late summer and moderating stream temperatures. Recent studies suggest glaciers have diminished in size today to their smallest extent in the last 4000 years (Pelto 2015). According to Pelto (2015), the mass balance loss in 2015 is the largest of the last 32 years in the North Cascades with losses averaging over three meters water equivalent. There is evidence that the valley glaciers on the north side of Mount Baker have receded an average of 5,000 ft since the maximum extent of glaciers at the end of the Little Ice Age in 1890. Further, these glaciers have receded approximately 1,000 feet just in the last 20 years, with the Mazama Glacier receding over 2,400 feet over that time. These trends transform into changes in the hydrology, thermal regime, and sediment dynamics of the Nooksack River. As glaciers recede, their over-steepened valley walls, primarily consisting of unconsolidated sediment, will be more vulnerable to mass failure, erosion, entrainment, and transport to channels. Increased rain intensity at high elevations will exacerbate this problem by oversaturating soils and causing landslides. Decreased snow accumulation on the glaciers and loss of glacier melt translates to decreased summer flows and higher water temperatures that may approach lethal levels to salmonids.



Recession of the glacier terminus at the Mazama Glacier since 1895. The Mazama Glacier is one of the larger glaciers to contribute streamflow and sediment to the North Fork Nooksack River.

Grah and Beaulieu (2013) discuss the implications of climate change and fish survival to members of the Nooksack Indian Tribe. Such climate changes will further adversely impact the Nooksack River in regard to available water, altered hydrographs and sediment dynamics, as well as suitable fish habitat and fish survival. As such, there is a real need to more accurately evaluate the hydrology, water temperature and sediment dynamics of the upper Nooksack River basin under today's conditions and more importantly in the future under various accepted climate change scenarios. Thus, establishing an adequate baseline of conditions today is fundamental to detecting change in conditions in the future with continued and projected climate change.

In addition to these field studies, we've contracted University of Washington (UW) and Western Washington University (WWU) to jointly model glacier ablation and altered hydrology of the Nooksack River and tributary streams with projected future climate change (Murphy, 2016). Further, we conducted an inventory of mountainous areas prone to mass failure and an assessment of recent glacier retreat from a series of aerial photos (Nielson, 2015). NIT also contracted two graduate students at WWU to model future stream temperature (Truit, 2018) and sediment dynamics (Knapp, 2018) with climate change projections.



The glaciers of Mount Baker and field sites monitored by the Water Resources Program.

Field Methods

Ablation Stakes

Four ablation stakes were inserted into the snow and ice of the Sholes Glacier in order to determine snow depth at the beginning, during, and end of the summer. The ablation stakes are roughly 200-300 feet apart in elevation, with ABL4 at the lowest elevation (5489 ft) on the toe of the glacier, and ABL7 at the highest point (6173 ft) on the glacier. Daily ablation rates are calculated by measuring the change in the snow/glacier surface relative to the ablation stake, then divided by the number of days between measurements. Snow depth was measured at each site, when applicable, by probing with a 10 foot sectioned metal wading rod. Ablation is then related to streamflow that is measured downstream.

Ablation stakes and stream gage/weather station locations at the Sholes Glacier.


Oliver Grah and Jezra Beaulieu measure melt rates at one of the ablation stakes on Sholes Glacier.

Streamflow and Stream Temperature:

Streamflow and stream temperature were monitored at both Sholes Glacier Creek and Bagley Creek in order to compare a glacier fed stream to a snow-fed stream. To estimate streamflow and develop a rating curve, we placed Leveloggers® in Sholes and Bagley Creeks to record water level, water temperature, air temperature, and barometric pressure. Each sensor was synced to 30-minute intervals so that relationships could be interpreted between the sites. We then measured discharge at each location during field visits throughout the summer to capture flow at various stage heights. Stream flow velocity was measured with a Xylem Flowprobe® then integrated over cross-sectional area to estimate discharge. A discharge rating curve was then developed for each creek in order to model continuous discharge over the field season from late July through mid-September.


Oliver Grah, the water resources program manager, measuring streamflow at the Sholes Glacier outlet stream.

Weather Station:

Weather conditions are monitored with a Campbell Scientific custom-made weather station that records air temperature, humidity, precipitation, and solar radiance. The station is in place from late July through September and data is downloaded during site visits.


Jezra Beaulieu, the water resources specialist, downloading data from the weather station at Sholes Glacier.

Turbidity and Sediment

Turbidity is measured and suspended sediment samples are collected at each glacier stream at every site visit throughout the summer to develop a sediment yield estimate for each stream. To measure the suspended sediment concentration (SSC) of the streams, we collect 1L samples of water concurrently with turbidity measurements, which are analyzed at the USGS Cascade Volcano Observatory (CVO). Regression equations between SSC, turbidity and discharge were developed to generate a continuous record of SSC at each station. Sediment loads are then calculated from the modeled continuous SSC and related to sediment loads observed downstream in the North Fork and Mainstem of the Nooksack River.

References:

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